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Implementation and Study of Universal Filtered Multi Carrier under Carrier Frequency Offset For 5 G

Sathiyapriya N.S

PG Student, Dept. of ECE, Periyar Maniammai University Thanjavur, Tamilnadu, India

ABSTRACT

OFDM is a matured technology and applied in various wireless standards. However they are not suitable for Uplink and this technology is replaced by SC FDMA in 4G standards. Similarly Universal Filtered Multicarrier Communication (UFMC) is another suitable technology for Multi user Uplink and for applications like cognitive radio. UFMC is a new, non-orthogonal, waveform designed by Alcatel Lucent Labs which provide a much more efficient way of enabling networks to serve both broadband users and very narrowband "short data" devices such as any embedded sensor or M2M module. In UFMC the filtering of waveform is done on a group of subcarriers. In OFDM it is done on the whole subcarriers together. This reduces the side lobe levels, inters carrier interference (ICI) and requires reduced filter length. Moreover Internet-of-Things where Machine-Machine communication and applications where very tight response in time requirements are needed, OFDM miserably fails. We examine impact of carrier frequency offset on the performance of the proposed scheme and compare the results performance of cyclic prefix based orthogonal frequency division multiplexing(CP-OFDM) system.-

Key words: ICI,CFO,OFDM,UFMC

I. INTRODUCTION

With the universal development of the 4G LTE standard, the wireless field is now concentrates on developing new technology for the next generation. Today's networks needs transmission of high-rate traffic, lower latency and high reliability to high-end devices like smart phones and tablets. With the arrival of Internet of Things and rising machine-type communications, a basic system redesign is essential for future 5G wireless communication systems.

OFDM (Orthogonal Frequency Division Multiplexing) is a 4G standard in which it divides the available transmission bandwidth into a number of non-overlapping and orthogonal subcarriers. It is employed in many communication standards like 3GPP LTE, Wi-fi and Wi-Max. OFDM has many advantages such as delivering high date rate, eliminates ISI (Inter Symbol Interference), reduce receiver complexity and provides spectral efficiency. However OFDM is sensitive to timing errors and Carrier Frequency Offset (CFO) errors. Filter-bank based multi-carrier (FBMC) is another technology considered to be a future 5G technology for replacing OFDM.[1]

FBMC is a multicarrier scheme like orthogonal frequency division multiplexing (OFDM). On comparing to OFDM, FBMC uses a prototype filter and the localization of the FBMC signal in both time and frequency makes it much more robust to frequency offset and timing error. But long filter length of FBMC makes it disadvantageous for short burst uplink communication [2].

Carrier Frequency offset in OFDM (CFO) is caused due to inaccuracies in local oscillator and Doppler Shift at the receiver side. There occurs a mismatch in carrier frequency of the signal from transmitter to the receiver side and the received symbols will have a time-variant phase rotation. Both the problem of CFO in OFDM and the long filter length in FBMC are overcome by our newly proposed Universal Filtered Multicarrier Technique (UFMC).

UFMC is an attractive technology for future 5G Wireless Communications. This scheme is based on the principle of frequency division multiplexing (FDM) in which we divide the incoming data stream into several sub-streams of lower data rate. UFMC has properties of reduced out-of-band radiations and provides better time and frequency synchronization [3]. In the upcoming chapters, we are going to discuss about the previous works of various authors, the methodology of UFMC and finally the simulation results of our proposed technique.

II RELATED WORKS.

[4] Describes the basics of OFDM and studied the effects of CFO and STO. They also provide us the technique to handle the STO and CFO using Cyclic Prefix and training symbols of OFDM. The authors estimates the STO based on

minimum difference and maximum correlation technique and CFO by Moose and Classen technique. [5] Investigates the effects of CFO in OFDM and SCBT (Single Carrier Block Transmission) and they categorize the problem into two types, with compensation and without compensation. They found that, In BPSK modulation the BER performance of OFDM is more sensitive to CFO compared to that of the SCBT and it achieves same score in QPSK modulation.

[6] Discuss the fundamental concepts of promising candidate of 5G, FBMC and compares the performance of OFDM with FMBC. They minimize the ICI and ISI by using MMSE equalizer at the receiver side. They strengthen the quality of the received signal by using this method. They carry out the comparison using MATLAB simulation and found UFMC outperforms the FBMC in terms of robustness and spectral efficiency.

[7]Investigates the drawback of FBMC and they overcome this problem by introducing unified frame structure. A new approach UF-OFDM i.e., UFMC is developed. In this the users are separated by means of interleavers as in Interleave-Division Multiple-Access (IDMA) which avoid the cross talk and utilize the capacity of Multiple Access Channel ion multi user scenario.

[8] Compares the multiple-carrier waveforms (OFDM and UFMC) and multiple access schemes (FDMA and IDMA). They eliminate the ICI in UFMC by using short length FIR filters. The simulation results illustrates IDMA outclasses FDMA for low rate users and UFMC provides protection to the high rate users. [9] Compares the popular multi carrier techniques OFDM, FBMC and UFMC. On considering Spectral efficiency, UFMC performs better than the other two techniques. The authors conclude that UFMC is the best choice where there short burst transmission occurs.

Therefore from the discussion of various authors it has been shown that UFMC is the best multicarrier technique.

III SYSTEM MODEL

3.1. OFDM

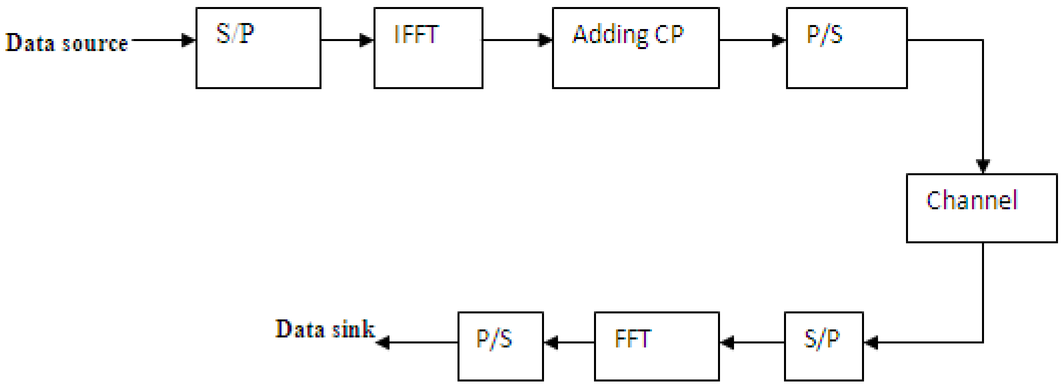

Fig 1 A system overview of OFDM

OFDM stands for Orthogonal Frequency Division Multiplexing is most prominent multi carrier modulation technique for broad communication. OFDM is special form of frequency division multiplexing. It applied in standard such as Long Term Evolution (LTE) and Wireless fidelity (Wi-Fi). It is simple and efficient modulation and demodulation stage using Fast Fourier Transformation and Inverse Fast Fourier Tranormations (IFFT).It allows scalar equalization at the receiver. Furthermore, high spectral efficiency can be achieved by overlapping the partial spectra of the subcarrier. Its main drawbacks are high spectral side lobe level and Inter Carrier Interference (ICI).It is due to the rectangular symbol shape in time. This makes OFDM vulnerable time-frequency misalignment

In the Fig 1,the system model of a conventional OFDM system is shown. First of all, the serial binary data are divided into several parallel sub carriers. OFDM system is the orthogonality between the subcarrier so that signal at the receiver side can be separated again. In order to avoid Inter Symbol Interference (ISI),a cyclic prefix(CP) of Ncp samples are added at the beginning of each OFDM symbol and each OFDM symbol block contain NB=N+ Ncp where N is Fast Fourier Transformation. The frequency domain signal Xk is converted into time domain signal x*k* by IFFT. The relation between Xk and x*k* can be written as

$$Xk = \frac{1}{\sqrt{N_s}} \sum_{l=0}^{Ns-1} X(l)\, e^{\frac{j2\pi lk}{N}} \quad (1)$$

K =0,1…N-1

Where Ns is the total number of the subcarrier. Afterward the parallel signal is again converted into serial signal and transmitted over channel. Hence, the received signal Y, which also corrupted by AWGN, can be written as

$$Y(k) = H(k)X(k)+W(k) \quad (2)$$

Where H(k) is the channel frequency response and W(k) is adding AWGN channeL

3.2.UFMC

In this section, we presented the proposed multi carrier transmission technique. This technique is developed on the principle of frequency division multiplexing(FDM). The overall bandwidth is divided into B sub band. The total number of sub carrier N. A sub band in UFMC may also correspond to Physical Resource Block (PRB) in LTE. Then, we use a pulse shaping filter with smooth edges on each resource block time domain that leads to substantial reduction in out-of-band leakage in frequency domain .Minimize the harmful interference from adjacent sub channel of neighboring resource block. Each sub band has NB group of subcarrier .A N-point Inverse Discrete Fourier Transform (IDFT) operation is performed for every sub band i to transform frequency domain Xi into time domain xi After IDFT operation in each sub band the output signal is filtered by FIR- filter with length L. The result in symbol length of N+L-1 because of linear convolution between xi and fi .The output signal of the subband i is given by

$$yi(k) = xi*fi \qquad (3)$$

The purpose of introducing FIR filter to filter each subband is reducing the out-of-band radiation. With block wise filtering approach in UFMC, out-of- band radiation can be significantly reduced by appropriately design FIR filter. Dolph-chebyshev filter can be parameterized in term of side lobe attenuation. It minimizes the maximum out-of –band radiation.

$$x(k) = \sum_{i=1}^{B} F * V * X \qquad (4)$$

Where F is defines as the toplitz matrix, with dimension [(N+L-1)xN] ,composed of Finite Impulse Response. X is transferred time domain by IDFT .V is include the relevant columns of the inverse Fourier matrix according to the respective sub-band position within the overall available frequency range.

The frequency domain output signal written

$$Y = H\tilde{Q}X + Z \qquad (5)$$

Where $\tilde{Q} = \mathrm{Col}\{\tilde{Q}1, \tilde{Q}2 \ldots.\tilde{Q}m\}$

In UFMC system, the zero forcing linear equalizer is used to detect the transmitted signals, performing multi antenna combing across the subcarrier, wchich suppress ICI and multi user interference.

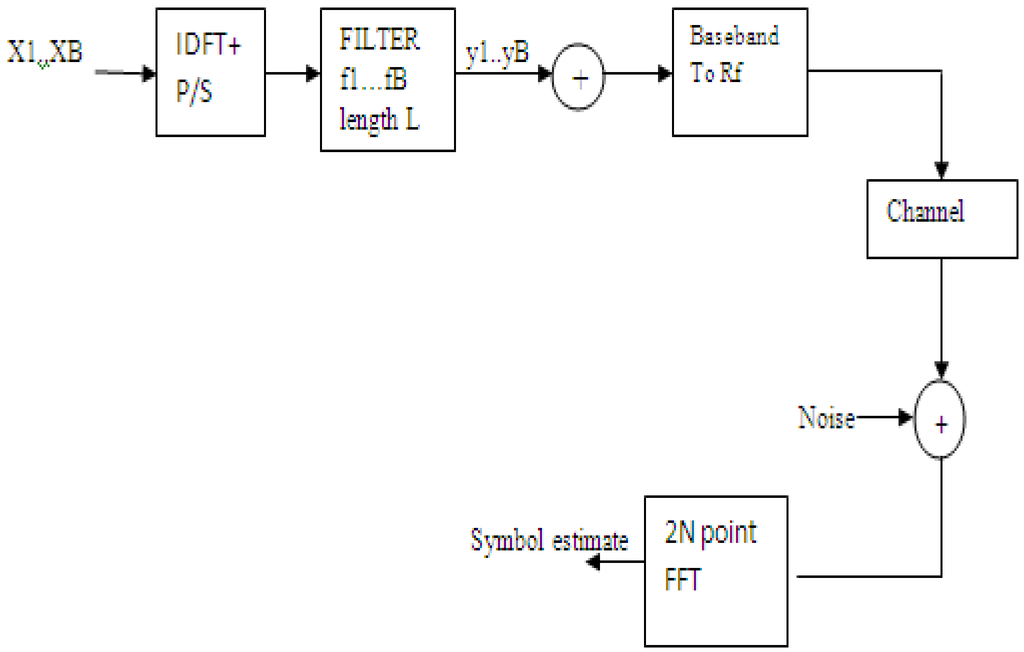

Fig 2 System model of UFMC

IV.SIMULATION RESULT

Simulation Result is compared to proposed system and OFDM in carrier frequency offset. the impact of carrier frequency offset error on the symbol error rate(SER) performance of system. we carried out simulation parameter ,filter length L=16,FFT size =128 ,bit per symbol M=2,number of subcarrier Nsc=6, allocated physical resource block RB=12 and QPSK modulation scheme.

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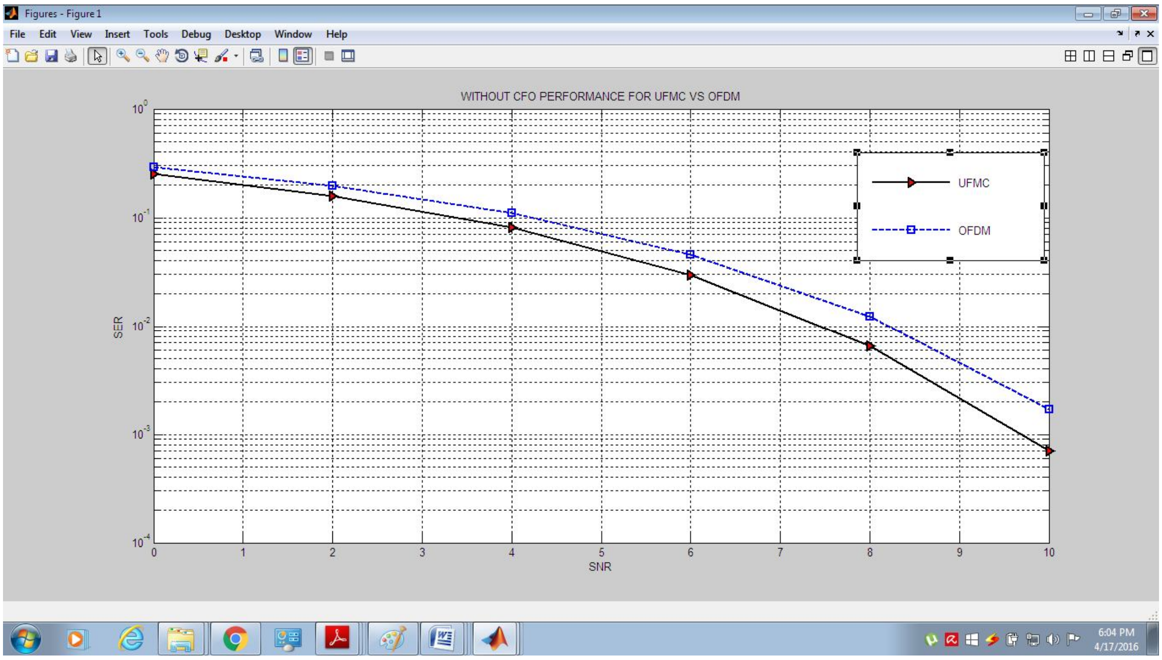

Fig 3 SER performance of UFMC and OFDM With no Carrier frequency offset

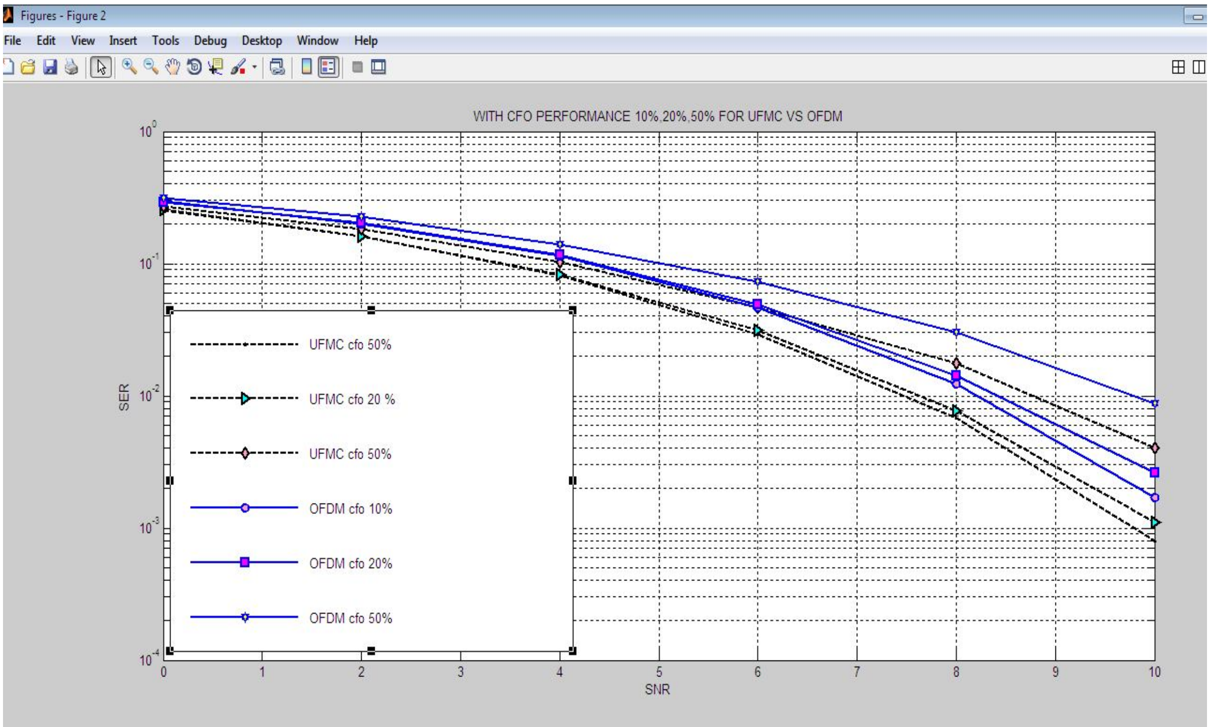

Fig 4 SER performance of UFMC and OFDM system for different estimation error

Fig.3 shows the symbol error rate (SER) of UFMC and OFDM systems versus SNR in no CFO scenario. In this figure, the proposed scheme outperforms the OFDM system, UFMC scheme provides higher spectral efficiency compare to OFDM due to the absence of cyclic prefix samples which has to be discarded at the receiver. Fig. 4 shows the SER performance of the proposed scheme and the OFDM systems in the presence of the CFO estimation error. The CFO estimation error value that is a percentage of the CFO. In this experiment, the CFO is chosen to be 0.1.we observe that the CFO estimation error severely degrades the SER performance of the system. For instance, as shown in the figure, by increasing the CFO estimation error from 10% to 50%, the SER increases from 10−3 to 10−2 at SNR = 10 dB. The proposed scheme with 20% CFO estimation error works better than the OFDM system with 10% CFO estimation error.

V.CONCLUSION

UFMC is multi-carrier transmission scheme in order to overcome the ICI problem and improve the system performance and filtering operation is applied to a group of consecutive subcarriers (e.g. a given allocation of a single user) in order to reduce out-of-band sidelobe levels that results in a better ICI robustness and better suitability for fragmented spectrum operation compared to OFDM. UFMC outperforms the CP-OFDM for both perfect and non-perfect frequency synchronization between the transmission and receiver side. The effect of imperfect CFO compensation on the SER performance of the UFMC system and compare it with that of the OFDM system.

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